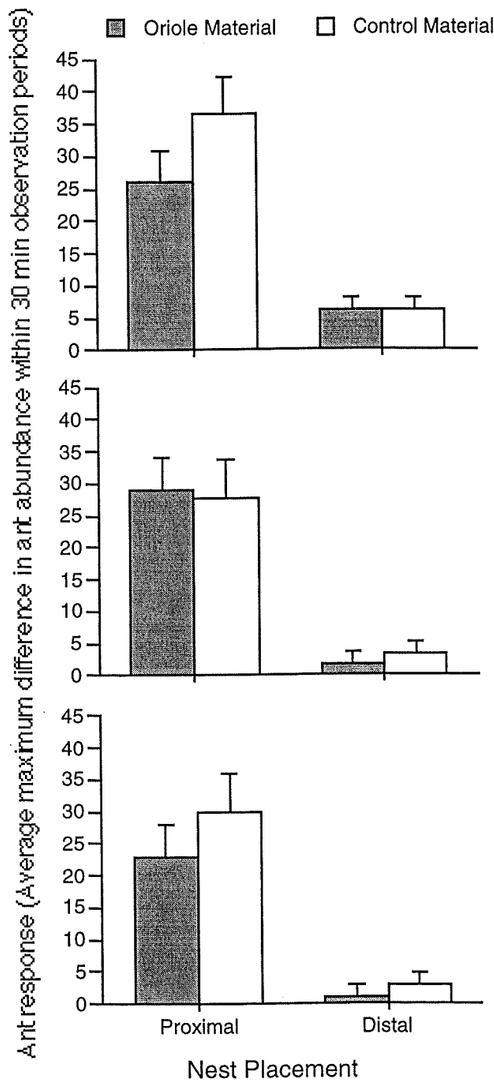

Fig. 1. Mean maximal difference (± SE) of ant defense-response to oriole and control nest materials in both proximal and distal positions over three consecutive 30 min time intervals (n = 4 trees). Time intervals 1, 2, and 3 are shown from top to bottom.

tation against nest predators for those bird species that can shield their nests from the ants. The streaked-backed oriole apparently protects its nests from ants by placing them in a distal position near the branch-tips of trees, where ant aggression is minimized.

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The effect of species assemblage on the size structure and condition of two isolated stream fish populations

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Abstract: Fish populations in isolated pools may be subject to different ecological conditions. We hypothesized that the presence or absence of cichlids (*Cichlosoma longimanus*) would affect the size structure of isolated tetra (*Astyanax fasciatus*) populations and the condition of individuals in those populations due to increased predation and competition. We conducted repeated visual censuses of tetra populations in two isolated pools located near the OTS Field Station in Palo Verde National Park, Costa Rica, to estimate the size distribution of the two populations. Additionally, we set minnow traps in the two pools for 24 hrs and recorded the length and weight of captured fish to compare the condition of the two populations. The pool with cichlids had significantly more small tetras and fewer medium-sized tetras than the pool without cichlids. There was no difference in individual condition between the two populations as indicated by the body mass/length relationship. Differences in size-structure between tetra populations may be the result of cichlids competing more directly with medium size tetras and thereby providing a competitive release for the small tetras. The lack of a significant difference in fish condition between the pools suggests that interference competition does not play a role in the interactions between the species. Stochastic differences in the species composition of pools that are isolated during the dry season may result in different selection pressures between pools and therefore contribute to the maintenance of genetic diversity within tetra.

Key Words: Astyanax fasciatus, Cichlosoma longimanus, *cichlid, competitive release, tetra*

Introduction

Genetic diversity may be maintained within a species due to periodic isolation of sub-populations that are exposed to different ecological conditions. Stream fish isolated in different pools during the dry season are likely to face different ecological conditions due to the random components of community formation. The fish community occupying any isolated pool must be partly determined by stochastic variation in the presence or absence of particular species at the time when pools become isolated.

Cichlids (*Cichlosoma longimanus*) and tetras (*Astyanax fasciatus*) are common fish species in the intermittent streams surrounding the OTS field station, Palo Verde National Park, Costa Rica. Both species are omnivorous (Bussing 1987) and of similar size; therefore, the probability for inter-specific competition and predation in isolated pools is high. We hypothesized that the composition of the fish community in isolated pools, specifically the presence or absence of cichlids, would affect the size structure and individual condition of tetra populations. We predicted that in pools with cichlids there should be fewer small tetras because small tetras fall within the gape size of larger cichlids and would be at risk of predation. We expected no difference between the pools in the proportion of medium to large tetras because they exceed cichlid gape size. In addition, we predicted that tetra in pools with cichlids should be in poorer physical condition relative to those in pools without cichlids due to decreased foraging efficiency from interspecific interference competition or predator-avoidance behaviors.

Methods

We conducted the study in two freshwater pools located 6 km apart along two

separate streams in the Palo Verde National Park, Costa Rica. One of the pools was 1 km east of the Palo Verde Biological Station on the north side of the road and the second pool was 4 km West of the Station off the north spur of the road. The pools are isolated along the streambed during the dry season, but linked to the stream channel during the wet season. These pools were of similar length, width, depth, volume, pH and canopy cover (Table 1). Preliminary observations and trapping showed that both pools contained populations of tetra, catfish (*Rhamdia sp.*), and mosquito fish (*Brachyrhaphis sp.*), but that cichlids were present in only one of the pools (Table 1). Both pools contained ≈ 80 – 90 tetras (Table 1).

Table 1. Characteristics of two study pools (with cichlids and without cichlids) in the Palo Verde National Forest. Length and width was recorded at the maximum distance. Depth was a range of three measurements, one taken in each third of the pool.

Pool	With cichlids	Without cichlids
Length (m)	6.20	4.24
Width (m)	2.95	2.91
Depth (m)	0.25 – 0.72	0.16 – 0.67
Volume (m^3)	8.96	5.42
pH	5.0	5.0
Canopy cover (%)	67	58
Estimated tetra population	94	81
Catfish	Present	Present
Mosquito fish	Present	Present

The size distribution of the two tetra populations was estimated by 18 consecutive visual counts of fish in the open water conducted at 3 min intervals over 1 h. We classified individuals into three size classes based on estimated length: small (< 53 mm), medium (53 – 70 mm), and large (< 70 mm). We compared the size distribution of pools with a chi-square analysis.

Individual fish condition was sampled by placing two minnow traps in each pool for 24 hours. Captured fish were weighed and their length was measured from the nose to longest point in tail. The mean length of tetra in each of the two pools was equal (mean ± SE = 58 ± 1.2 and 58 ± 2.1 for cichlid and non-cichlid, respectively). Therefore, we were able to compare the residuals of a regression between length and body mass (Mass = -7.28 + 0.183•Lengh, $r^2 = 0.78$, $P < 0.001$) using a one-way ANOVA to determine whether fish condition differed between the two pools.

Results

The size distribution of tetras differed between pools (chi-square = 12.19, df = 2, $p < 0.005$). The pool with cichlids contained a higher proportion of small fish and a smaller proportion of medium fish than the pool without cichlids (Fig. 1). There was a similar proportion of large fish in the two pools (Fig. 1). There was no difference in the condition of tetra populations between the two pools (n = 36, 13 for cichlid pool and no cichlid pool respectively; t = 0.12, df = 1, p = 0.91).

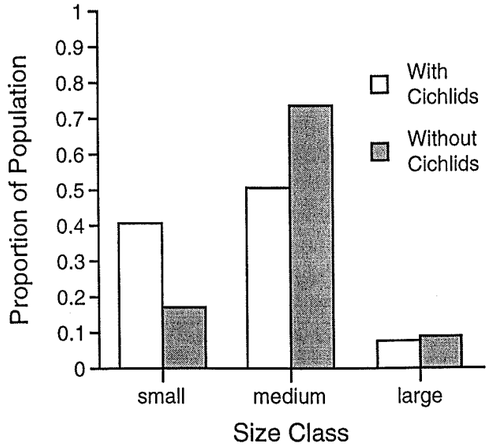

Figure 1. Population size structure of *A. fasciatus* in two isolated stream pools in Palo Verde National Park, Costa Rica (with cichlids, n = 94; without cichlids, n = 81).

Discussion

Contrary to our prediction, the presence of cichlids was associated with a high abundance of small tetras instead of a lower proportion. Cichlids were also associated with a reduced proportion of medium tetras. The lower proportion of small tetras in the pool without cichlids may result from a combination of interspecific competition and intraspecific competition between size classes of tetras. Due to size overlap, cichlids may compete directly with medium and large size classes of tetras, allowing the small tetras to experience some degree of competitive release from larger individuals of their own species when cichlids are present. This competitive release may lead to larger proportions of small individuals in pools where cichlids are present than in pools where they are absent. Likewise, the lower proportion of medium-sized tetra in the pool with cichlids may be the result of intense size-mediated competition between tetras and cichlids within this size class.

It is also possible that our results do not describe a general consequence of the presence of cichlids. Indeed, we were only able to study one pool of each type, so the patterns could be due to other differences between pools that were unrelated to cichlids. For example, the abundance of catfish or mosquito fish may influence the size structure of the tetra populations, and in fact, we observed catfish preying upon small tetras. Future studies of this system might benefit from addressing the role of catfish predation.

In seasonally-intermittent streams, stochastic differences in the initial species composition of pool communities that are isolated during the dry season, and subsequent mixing of sub-populations during the wet season, may have important effects on the evolution of stream fish species. Specifically, if the community compositions of isolated pools are sufficiently different, the resulting diversity of selection regimes during the dry season may maintain genetic heterogeneity within stream fish. These selective forces may be amplified over the course of the dry season as resources become limited. In the Palo Verde National Park stream system, some groups of tetra spend the dry season without cichlids, while others are confined to the presence of cichlids. This may contribute to the maintenance of genetic diversity within this tetra population.

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